the Atom

Los Alamos Scientific Laboratory
November, 1978

theAtom

VOL. 15, NUMBER 9
NOVEMBER, 1978

ON THE COVERS:

Shimmering aspens, stately ponderosa pines, and mountain meadow land provided the incentive to PUB-1 photographer Bill Jack Rodgers for this study of autumn changes. He found the scene in the Jemez Mountains on the St. Peter's Dome Road.

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Published monthly except for July-August and January-February issues by the University of California, Los Alamos Scientific Laboratory, Office of Public Information. Address mail to MS 318, P.O. Box 1663, Los Alamos, New Mexico 87545. Second class postage paid at Los Alamos, N.M. Printed by Panorama Press, Albuquerque, N.M. ISSN 0004-7023.

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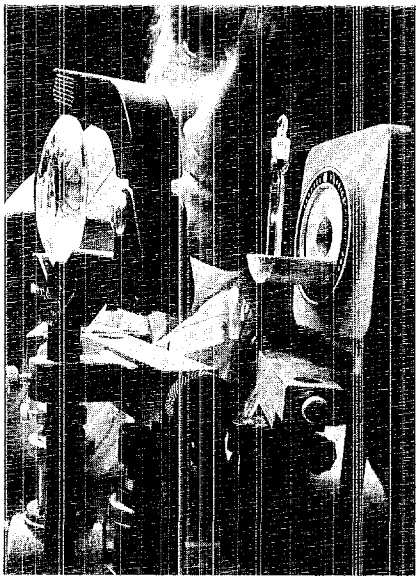
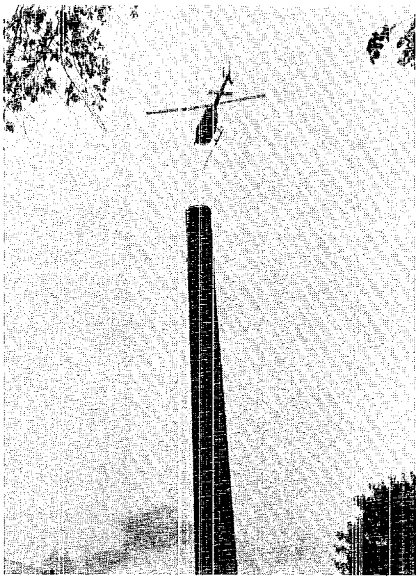
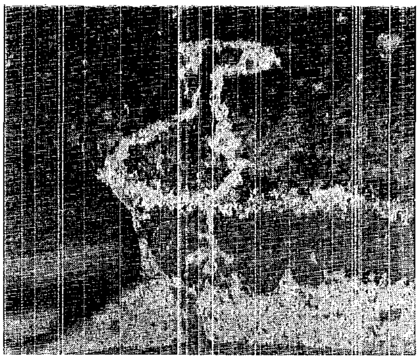






The solution to be excited by the laser is contained in the small glass cuvette in the center of the photograph. The spot of light on the cuvette is caused by the laser pulses. The lens on the left focuses the light emitted from the cuvette before it enters the streak camera. Shown is Ken Winn, AP-4.

Laser pioneering with the 'pH jump'

By Charlie Mitchell

Show a child a new bug and he will poke the bug to see what it does, every time. Show a chemist a new phenomenon and he too will poke it to see what happens. His technique for poking it will be a lot more sophisticated and his analysis of the response will sound terrifically impressive, but the basic principle is the same. A lot of the progress in science has depended on the development of more subtle and faster techniques for tweaking physical systems. A group in Applied Photochemistry (AP) Division has pioneered a unique and extraordinarily fast tweak called the "pH jump" which will be important for the study of both chemical and biological processes.

The term "pH" is familiar to anyone who has (1) taken beginning chemistry or (2) sat in a beauty shop for any length of time and read the walls. This quantity is a measure of whether a solution is acid or basic (basic and alkaline mean the same thing). Gardeners, buyers of shampoo, and eaters of Tums are familiar on an instinctive level with how important pH can be to biological systems.

Remember litmus?

The term "pH" is simply a chemist's shorthand notation for the acidity or basicity of a solution. Many of us can remember trying to determine pH in high school chemistry using litmus paper which turned different colors according to the pH of the solution. In fact, pH is a measure of the concentration of hydronium ions (H_3O^+) -- that is, water molecules with protons attached to them.

The pH of pure water (an essentially neutral substance) is seven. Acids have a lower pH and bases a higher one. Just like the Richter scale for earthquakes, the pH scale is logarithmic. In other words, a change of one pH unit represents a change of a factor of ten in the H_3O^+ concentration.

The basis for the AP work on pH jump is a well-known chemical phenomenon; namely that molecules in excited states often have dramatically different acid/base properties than those same molecules in their ground states. The ground state of a molecule is its "normal" state. Excited states are achieved by a molecule absorbing some of the energy from the laser light. The difference in the acid/base properties of ground state or excited state molecules can be extraordinarily large, as much as 1,000,000,000,000,000,000,000,000-000,000 times (a million-trillion-trillion). Depending on the structure of the molecule, it can become either more basic or more acidic when it is in an excited state.

The term is a chemist's shorthand for the acidity or basicity of a solution. The pH of pure water is seven, essentially neutral.

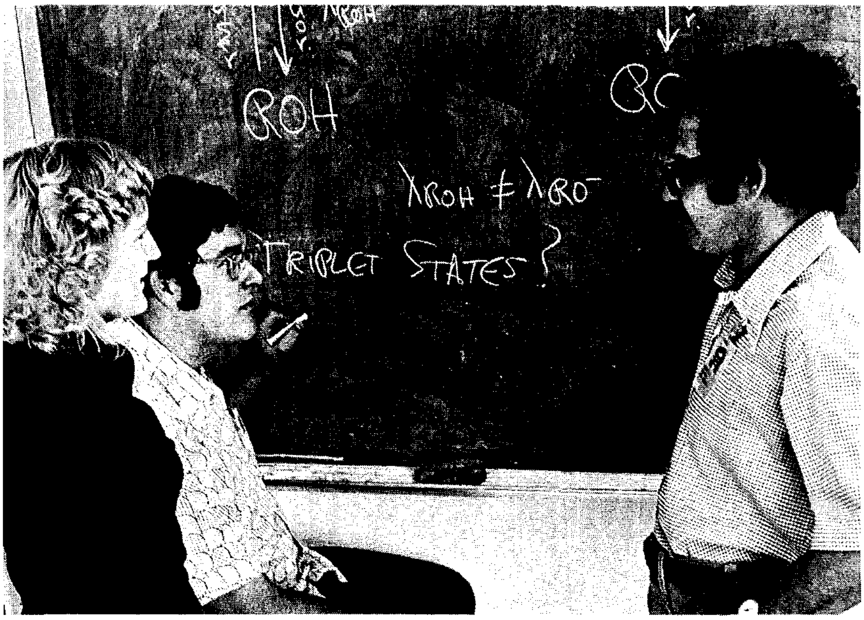
The real chemical definition of acids and bases is that acids are compounds that like to give off protons, while bases like to take up protons. This means that the chemistry of acids and bases is the chemistry of the proton, or H^+ ion. Once this connection is made, we can begin to understand why acids and bases are so important to chemistry, for the proton is a unique chemical entity. It is a naked positive charge, the only ion which has no electron. Because it lacks an electron, it is very small, with a radius 100,000 times smaller than the next smallest ion.

This combination, a small size and an unshielded charge, makes the proton one of the most reactive chemical species. This in turn explains why acid/base reactions play such an important role in chemical and biochemical processes. The high reactivity of protons creates a problem for chemists because the reactions of protons are exceedingly fast, and therefore very difficult to study.

Ultrashort pulse

John Clark, Stanley Shapiro, Anthony Campillo, and Ken Winn, of the AP-Division, have applied ultrashort laser pulse techniques to the study of proton transfer reactions, the most fundamental process in the chemistry of acids and bases. With their system, the AP-Division personnel can initiate a pH jump and study reactions which occur in a picosecond (one-trillionth of second) time scale. (A picosecond has the same relationship to one second as one second has to 30,000 years.) The information gained from their study of proton transfer reactions forms the basis for the new and very general method for initiating chemical and biological reactions on a picosecond time scale.

The idea of a sudden, uniform change of "jump" in some property of a chemical system has been previously exploited by such techniques as the temperature, or T, jump and has been instrumental in allowing chemists to unravel many of the details of thermal chemistry. The AP-Division technique is the first method developed for jumping what is one of the most important solution parameters -- its pH. Previously, the only means one had for changing pH was to add an acid or base.



Paula Woodbridge (left) and Stanley Shapiro (right), both of AP-4, discuss the effects of laser excitation of a 2-napthol-6-sulfonate solution with John Clark, AP-3, who is a J. Robert Oppenheimer Research Fellow.

Photos by LeRoy N. Sanchez

Even under optimum conditions, thorough mixing of the added acid or base takes a large part of a second. Therefore, any attempt to study fast reactions is doomed to failure. The laser technique produces the very rapid jumps needed to explore the fast reactions which typify solution chemistry. Although it is still in an early stage of development, the laser pH jump is already the fastest of all the jump methods available to chemists.

By exciting a molecule in solution, for example 2-napthol-6-sulfonate (more simply ROH), with a picosecond laser pulse, the AP researchers can create excited molecules which are over 10 million times more acidic than the ground state molecules. These molecules now have a much greater tendency to give off a proton and transfer that proton to one of the surrounding water molecules. This produces a hydronium ion and the negative ion (RO^-) of the excited ROH molecule. By photographing the light radiated from such a laser-excited solution, the AP-Division workers can identify how rapidly these processes occur. The measurements of the light from the solution are made by an ultrafast streak camera. Previous attempts to measure these rates with other methods failed because the reactions were much faster than the methods available to study them.

The laser technique provides the first general method whereby the rates of these excited-state proton transfer reactions can be obtained. As such, this technique should provide chemists with their first real look into the detailed mechanism of the process. The laser measurements also established that the change in pH was achieved in a very short time when compared to the natural decay time of the excited state. It was this observation which ensured that a laser could be used to photochemically change the pH of a solution.

pH from 7 to 4

Under the conditions used in the AP-Division experiments, each absorbed laser photon instantaneously produces an excited ROH molecule, which produces an H_3O^+ ion long before the molecule excitation decays away. Because the laser pulse is very intense and is focused into a small volume, an appreciable concentration of H_3O^+ was produced in picoseconds. Indeed, even in these initial experiments, the pH could be changed from 7 to 4 — a change of a factor of a thousand. Larger jumps can be obtained simply by increasing the laser power.

The potential power of this technique to *increase our understanding* of the chemistry of solutions is that it allows the use of picosecond lasers for the initiation of ground state reactions. Previously, only photochemical reactions (that is those involved excited states) could be studied. There are very few such systems (for example photosynthesis and the visual processes) but they are of great importance. With the laser pH jump, the vast number of "normal" (that is ground state) reactions can be studied. In both chemistry and biology, the simplest and most fundamental reactions are almost always also the fastest. The laser pH jump may give chemists their first chance to study these reactions in detail.

Simply being able to take a precise look at the many steps in chemical and biological reactions is

They can initiate a pH jump and study reactions that occur in a trillionth of a second time scale. The laser jump is the fastest of such methods available to chemists.

of enormous value because it compounds our knowledge. In addition, the scientists in AP-Division are already starting to envision some of the many practical applications for this process. Some of the most intriguing are studies on proton transfer in biological systems.

Hydrogen bonding is the basic process by which nucleic acids are assembled into complex structures, such as DNA and RNA. Since proton transfer is thought to play an important role in the formation of these hydrogen bonds, an experimental technique, such as the pH jump, with which to study such proton transfers could lead to a better understanding of the formation and structure of DNA and RNA.

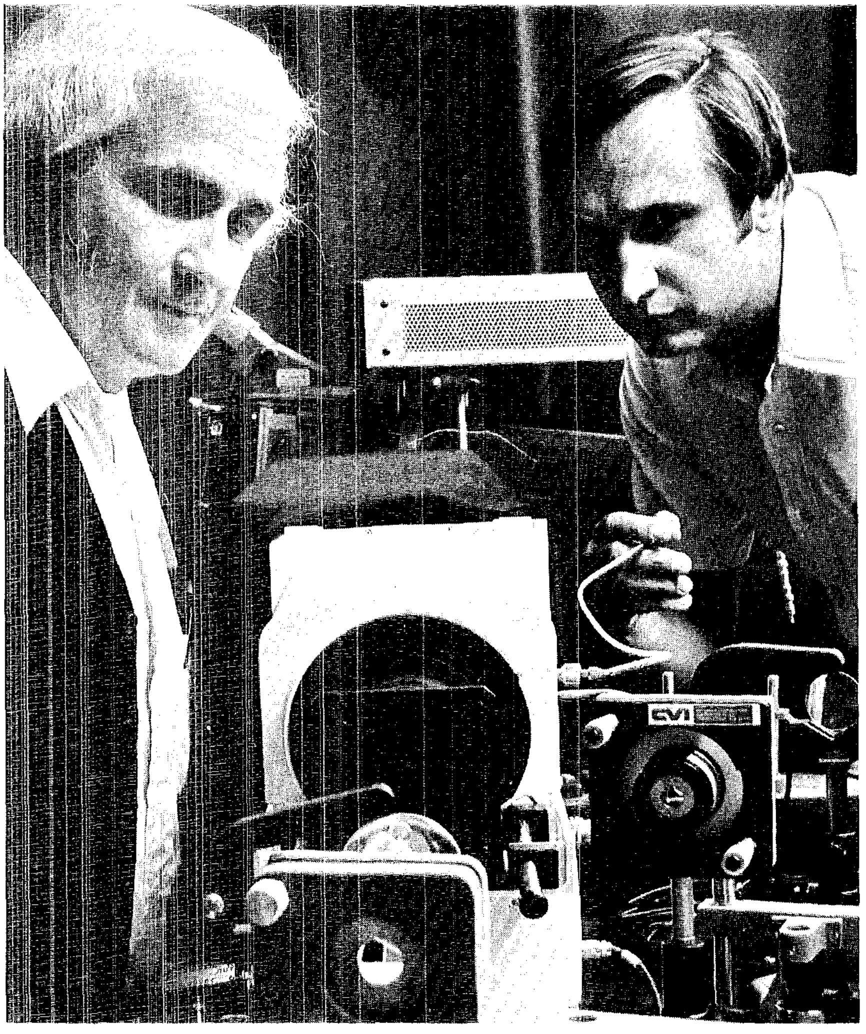
Chlorophyll-based photosynthesis has long been thought to be the only means by which nature can convert sunlight into chemical energy. Recently, however, it has been discovered that a particular bacterium exploits a different photosynthetic mechanism based on a photoreceptor called bacteria rhodopsin, rather than on chlorophyll. This type of photosynthesis stores energy by a sequence of proton transfers which eventually result in the storage of chemical energy. Once again, the as yet unknown details of this process may be opened to study by the laser pH jump.

Intriguing applications

There are other intriguing applications of laser pH jump in chemical separation procedures. One such application is to nuclear waste processing. The traditional method of reprocessing spent nuclear fuel is to dissolve the fuel rods in some strong acids. Once a solution has been obtained, various individual components or compounds are extracted by chemical precipitation. This process works well if only one product is to be extracted, but problems arise and are compounded when one tries to extract a number of things in sequence. Since the extractions are often pH-dependent, the addition of acids or bases is necessary to obtain the desired separation. Each such addition increases the total volume of waste which must ultimately be disposed. Furthermore, the solution can become buffered, which makes it more and more difficult to change the solution to the desired pH.

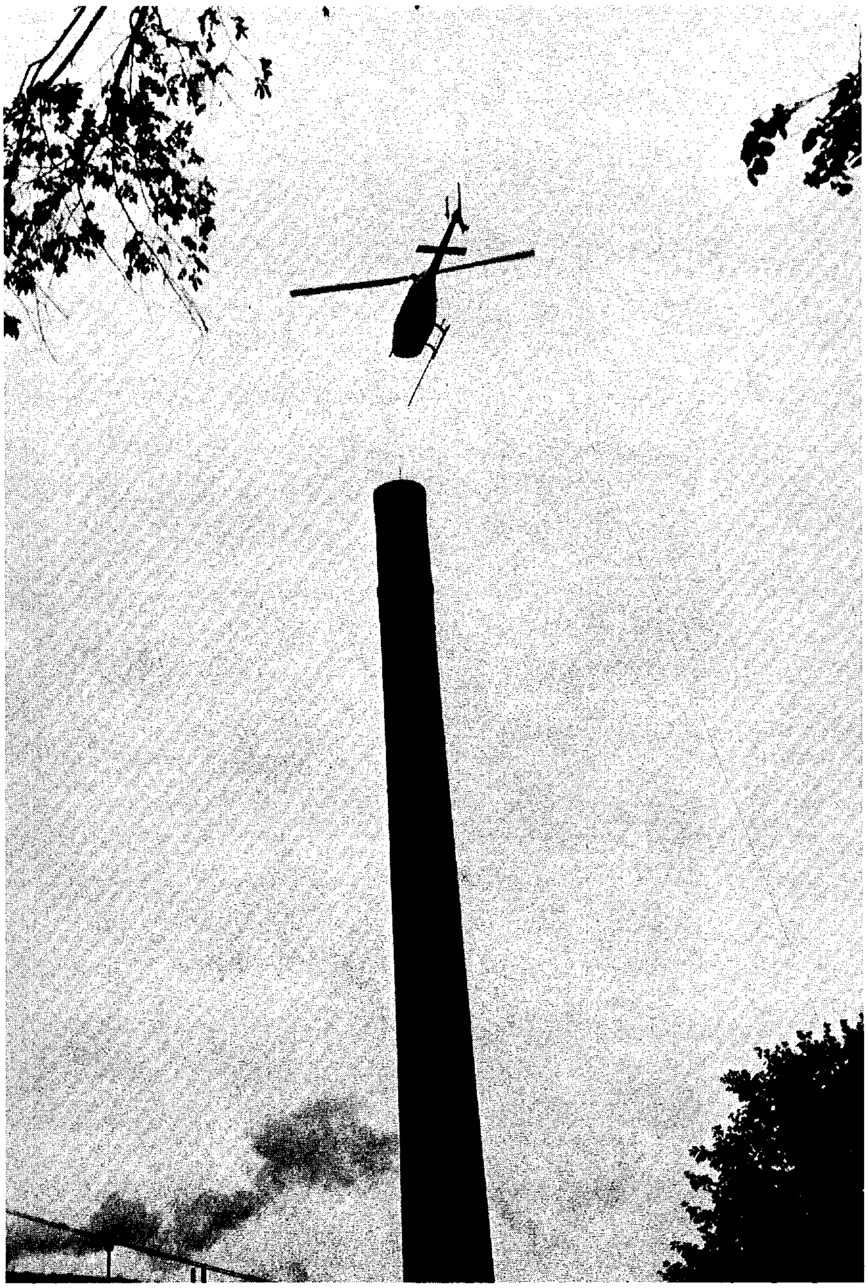
The pH jump method, dependent only on the wavelength and intensity of the laser light, could change the acidity of nuclear waste solutions much like the addition of chemicals. However, the laser-induced pH change would be reversible. The solution always returns to its original state automatically after the laser is turned off. This offers the opportunity for changing the pH so as to precipitate out a specific component of the mixture without increasing the volume of waste or irreversibly changing its acid/base properties. If realized in practice, it could provide a new and powerful tool for chemists concerned with complicated chemical separations such as those required for nuclear waste reprocessing.

The concept of pH jump, and AP-Division's ability to apply this concept to the study of chemical reactions, has given us yet another method of understanding many complex processes which open more doors to improving the world around us.



Ken Winn and Tony Campillo of AP-4 check the laser alignment to ensure that the beam enters the streak camera (white device in center) with the proper orientation.

Through a chimney


A helicopter was modified so samples could be taken from the top of the stack and downwind.

Study in Vermont

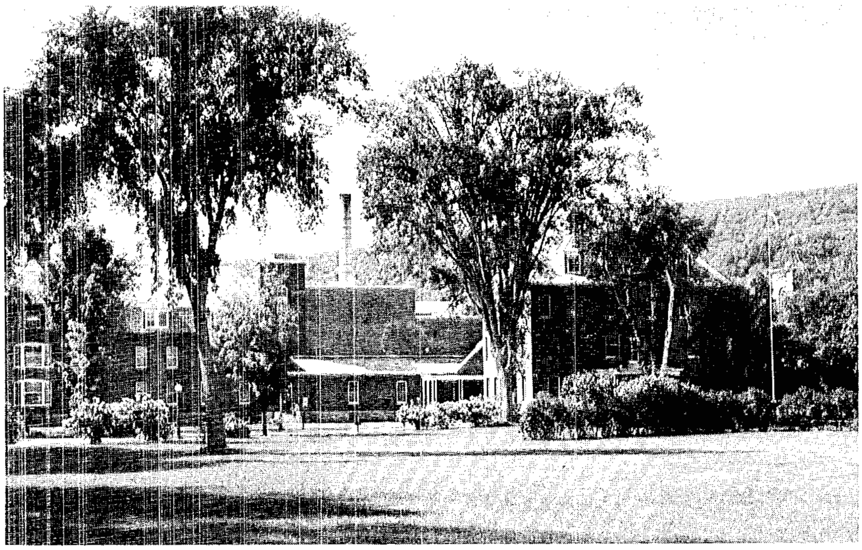
By Jeff Pederson

The state is covered with rolling forest and its people have a long history of self reliance. But it also imports at least half of its energy needs, so it made sense to the Vermont legislature in 1977 to convert part of a state boiler system from fuel oil to wood chips.

The intent was not unique; serious consideration is being given in many states to the use of renewable resources, such as wood and wood waste, for power production. But when mention is made of a switch from limited fossil fuels, environmental and economic problems may also result — air quality can be subject to change, and wood products can be expensive to transport from a forest area to a power facility.

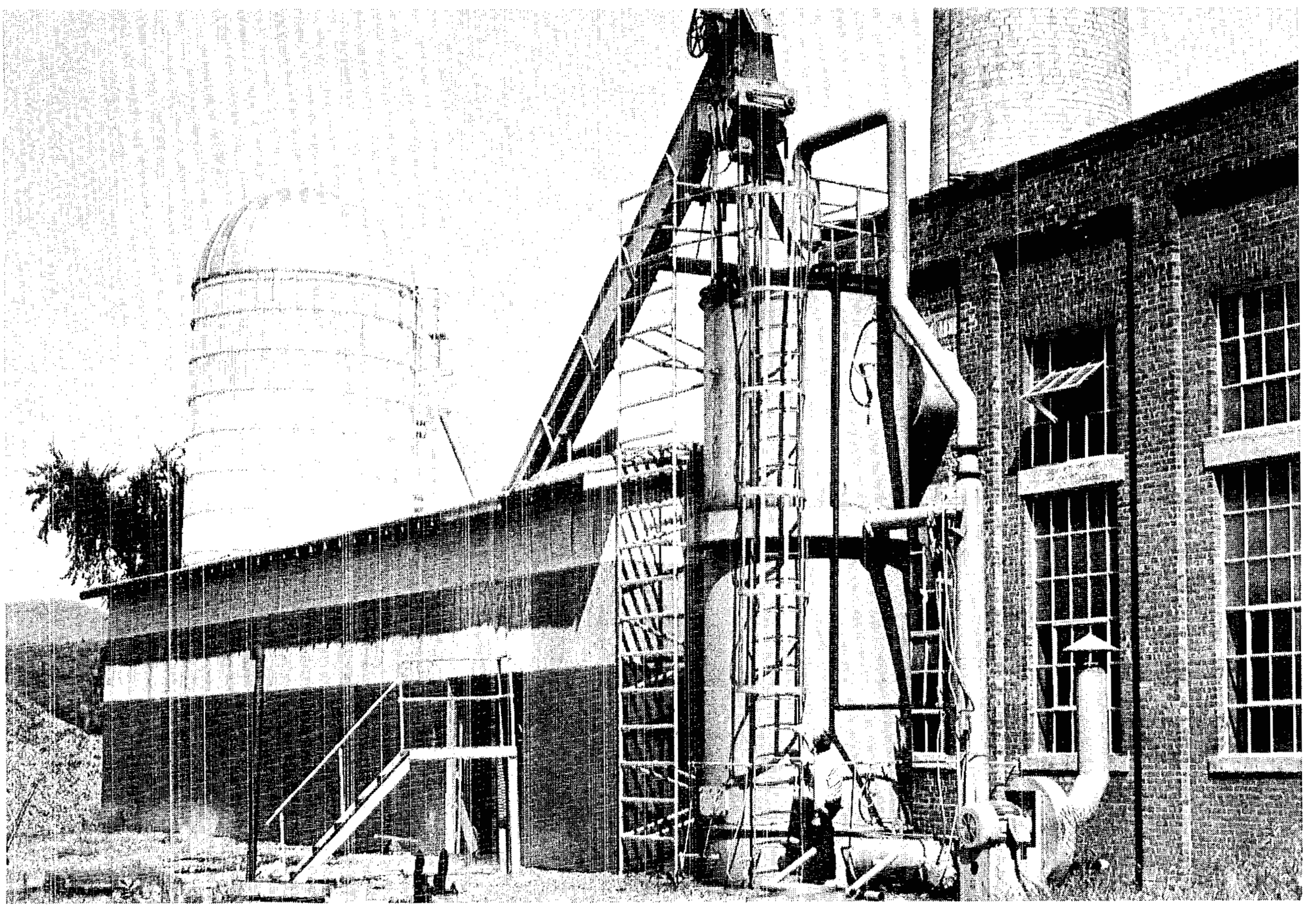
The Department of Energy is also interested in the use of alternative fuels, and a Los Alamos Scientific Laboratory investigative team traveled last month to Waterbury, Vermont, on its behalf. Waterbury, where one boiler at the Vermont State Hospital and Office Complex is partly fired from wood chips produced in the adjoining Duxbury State Forest, was chosen over six other sites after the team visited operations from Washington state to Alabama. Nearly 20 persons, representing three LASL groups and the University of New Mexico, ran a number of tests in the course of a week. They bolstered their fields of study and found out why some of the 1,700 wood boilers in the United States do not meet federal standards for opacity -- the plume coming from stacks is often too dark.

A helicopter was modified to sample effluent gases at the top of the 150-foot stack; measurements were also made at the stack mouth and downwind. Studies were made of the wood chip fuel and of pollution control equipment. A device called a photometer, operated by Clint Shirley of the University of New Mexico, measured the contrast of the plume against the normal background scene at a number of locations. Fluorescent particles, inserted into the bottom of the chimney, were collected at downwind locations and analyzed.



The Vermont State Hospital and Office Complex, with brick smokestack in the background.

Photos by Ellen Leonard, Bill Clements, and Jeff Pederson



The Waterbury power house, rear side, showing chips, loading area, conveyor, and cylindrical vessel with hot, lava-like sand at bottom.

Some of the 1,700 wood-fired boilers in the United States do not meet federal standards for opacity.

Surface winds were checked at points along the picturesque Winooski River valley, and meteorological sounding balloons helped determine the nature of the winds – and the depth of the mixing layer in which pollutants would be confined.

Fitting the model

"The experiments were also worked out to fit our model of how a power plant plume would look," explained Ellen Leonard, a staff member in the Energy Systems and Analysis Group (S-2) of the new Systems, Analysis, and Assessment (S) Division. "The experiments fit in well, based on the scattering of light in the atmosphere. The opacity of the plume is related, among other things, to the sizes and types of particles. The particles form quite rapidly from the gaseous state upon cooling, and become very effective light scatterers when they leave the stack – in other words, you can see the plume."

At Waterbury, wood chips made their way up a conveyor belt and were dropped into a vessel that contained hot, lava-like sand that had been heated by an oil burner to 800 degrees F. The chips, being wood products and containing mostly volatile substances, were ignited before they hit the fluidized sand bed. The energy released was used to power a water boiler that sent heat to the laundry and kitchen.

A cyclone device was supposed to remove the particulates after the chips burned; instead, there were more particulates in the exiting smoke than there were before the gases entered this anti-pollution precipitator. The gases cooled off in the cyclone and condensed to form particles, a relatively common problem of wood-fired plants.

Another conclusion reached: a wood plant differs greatly from a coal-fired plant in terms of emissions. Bill Sedlacek, of the Nuclear Chemistry Group (CNC-11) of the Chemistry - Nuclear Chemistry (CNC) Division, helped with measurements of the particulates and their size distribution. His equipment included an interesting piece of hardware termed a quartz crystal microbalance cascade impactor that separates particles by size, and then weighs them – in small, nanogram qualtities – to give a mass versus size distribution. Particle shapes and elemental compositions can be determined by subsequently using a scanning electron microscope, x-ray fluorescence, and neutron activation analysis for each of the separated size fractions.

"The physical chemistry is apparently very different in a coal-fired plant," Sedlacek said. Coal ash normally contains large quantities of silicates, but the primary products of wood combustion are salts of sodium, calcium, and potassium. These salts have lower melting points than the silicates, as low as 300 or 400 degrees C. The silicates form particles much earlier in the process, providing a collecting surface on which other emissions can condense. In a sense, they act as a sort of scrubber in a coal plant. But, in a wood plant, the fuel residues are beyond the anti-pollution devices before they become particles sufficiently large to be removed.

The significant thing we learned," Sedlacek continued, "is that different emission controls are called for at coal plants and at wood

Teymoor Gedayloo, G-8, released fluorescent particles into the brick chimney so they could be gathered and counted later, giving an indication of the plume's behavior.

plants." This is supported by data gathered at many points in the combustion system, by measurements of particle sizes, and by analysis of concentrations of light scattering particles (made by Mike Williams, a John Muir Institute consultant to S-2).

A 50-megawatt plant would require 150,000 acres of trees over a 30-year lifespan.

Not EPA methods

Williams noted, "When ambient air was mixed with the hot exhaust gases, the light scattering particle concentrations increased dramatically." Sampling methods such as those used by the Environmental Protection Agency, and which are not taken from the stack top, will give misleading results, he continued. "It is easy to see why these facilities appear to have low emissions when sampled in the normal fashion, but nevertheless have difficulties meeting restrictions on visual plumes," Williams concluded. "Most of the particles that produce the plume are formed downstream of the measurements."

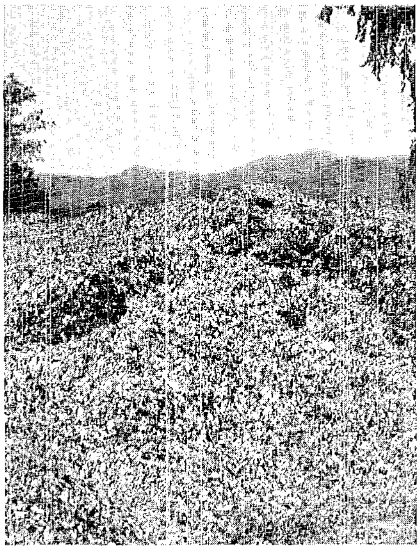
Dave Kauffman, a faculty member of the Chemical and Nuclear Engineering Department, University of New Mexico, agrees. The main interest of the three persons from the University who went to Waterbury was to pin down how the wood-fired furnace and boiler operated. "If you're burning wood, you'll get emissions that affect visibility more than coal," he said. Equipment installed to reduce air pollution at coal plants may not be effective on wood facilities, he added.

Kauffman also said that while the plume from wood plants may not look appealing, it very likely is no worse, in terms of the effect on people, than a modern coal plant. "There at least is not the sulfur dioxide problem associated with coal," he said.

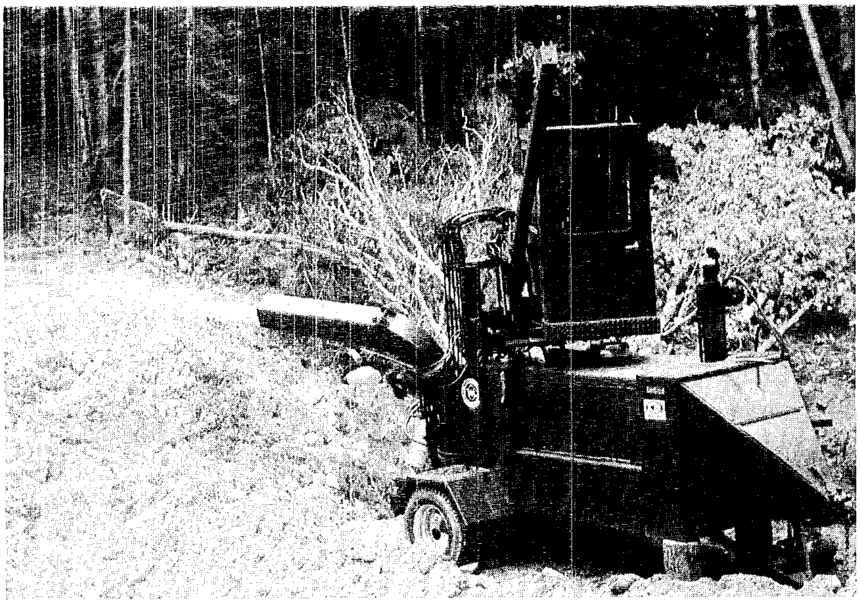
"In fact," Sedlacek noted, "the highly basic sodium, potassium, and calcium oxides that are produced upon the burning of wood probably act as efficient scrubbers for any acidic sulfur gases that are produced. If those particles were removed properly, a wood burner could potentially be very clean."

In one sense," Kauffman said, "the stuff from a wood stack would be decaying on the forest floor anyway. Of course, it is more concentrated when it comes from a chimney." Wood provides a reasonably good supply of thermal energy at Waterbury, but also is less flexible than oil or gas when one desires to turn the level up or down.

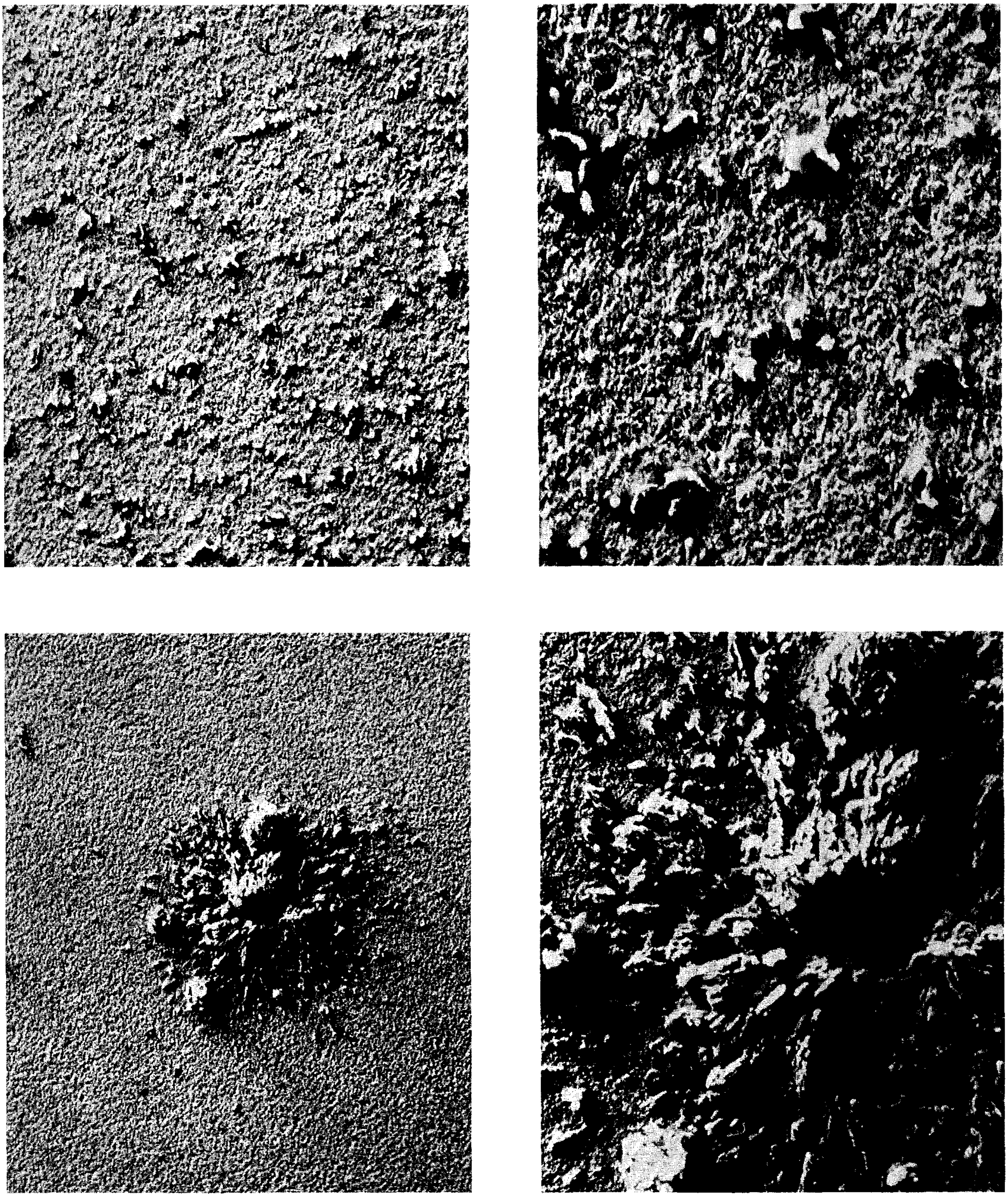
What goes into the chimney often comes out, and as particles drifted away from the smokestack, they were of concern to Bill Clements and other members of the Atmospheric Sciences Group (G-8) of the Basic and Applied Geosciences (G) Division.



Outdoor storage has sometimes meant a wet wood supply, but state officials are optimistic for the first full winter's run.



The Waterbury project has started, as an offshoot, an embryonic wood chipping industry where a contractor provides chips for the boiler.

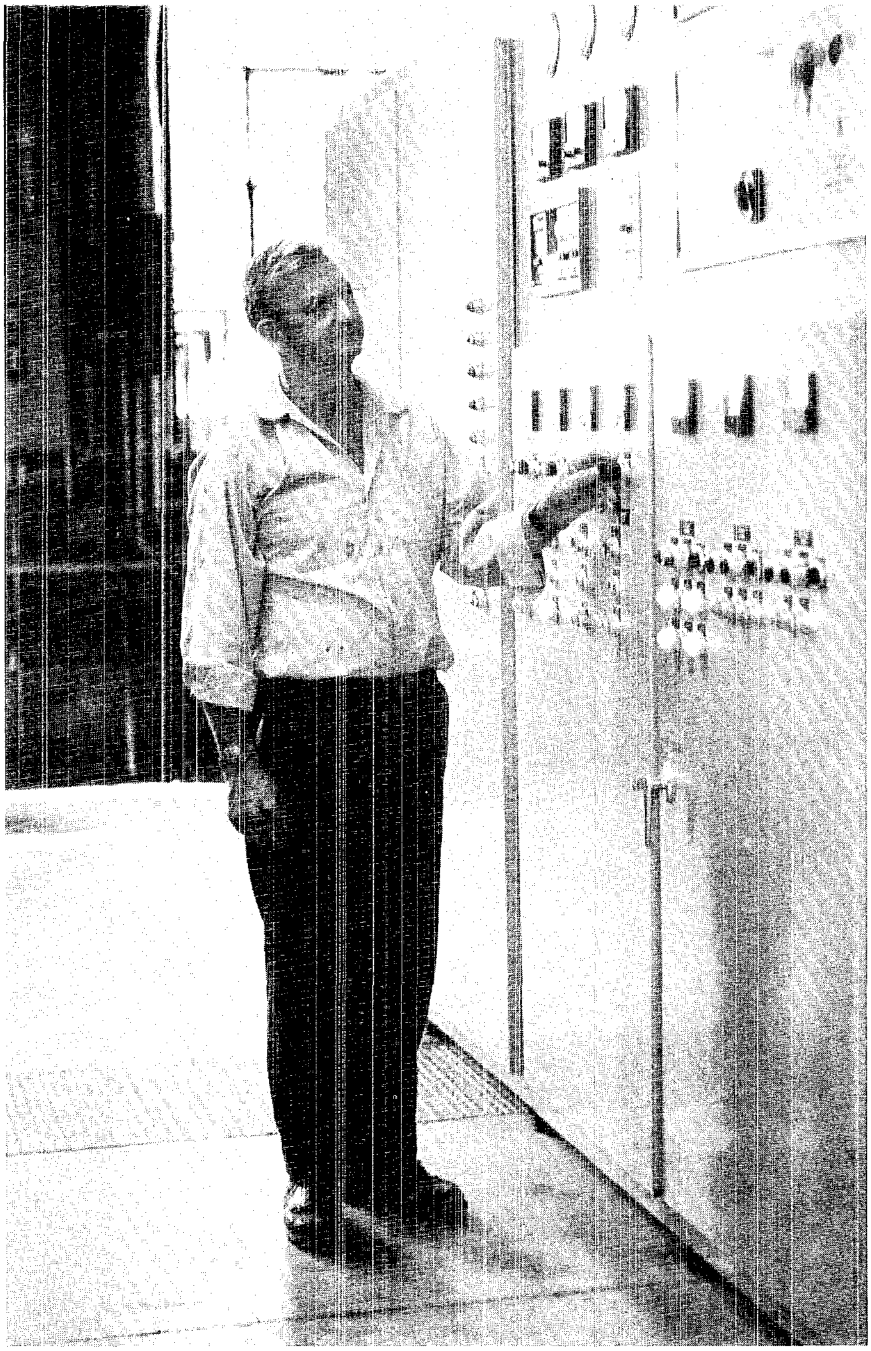


Bill Sedlacek photos

Particle samples from the Waterbury, Vermont plant as seen through an electron microscope. Top left: 300 magnification. Top right: 1,000 magnification. Both have particles in the 3.2 to 6.25 micron diameter range and elements present were calcium, potassium, sodium and manganese. Lower left: 100 magnification. Lower right: 300 magnification. Both have particles in the small 0.1 to 0.2 micron diameter range and elements present were potassium and sodium.

"We're basically interested in the transport of pollutants," he explained, "and the interaction of the motion of the winds with mountains, valleys, canyons, and other features. With many energy-related activities located or being considered in complex terrain, it is important that we understand what happens when pollutants are released in these environments. So besides collecting data for the experiment, this was an excellent opportunity to add to our overall knowledge of wind behavior."

One of G-8's findings in Vermont: due to a much smaller day-to-night temperature difference than exists in the West, there is less of a local mountain-to-valley wind circulation in the Winooksi valley "airshed" than was expected.



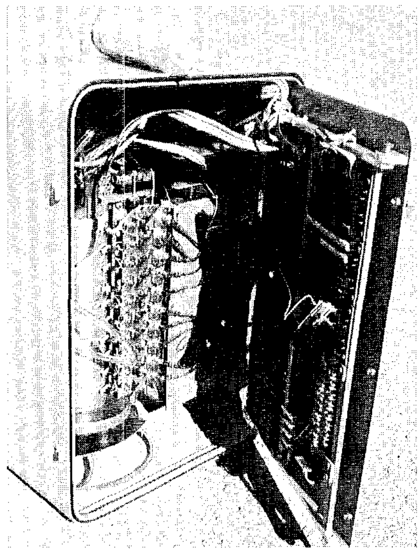
State fireman Fred McAdam at boiler controls. In the winter, 4,000 gallons of fuel oil must be burned every 24 hours at Waterbury.

Whole trees to chips

The Waterbury plant is used to produce heat; if it generated electricity, it would roughly be rated at three megawatts. In contrast, the Algodones plant north of Albuquerque is a 45-megawatt operation, at its maximum rating.

At Waterbury, there are 350 patients at the Vermont State Hospital and 600 employees at the state office complex. The power plant burned coal when it was built in 1925, and was converted to oil about 17 years ago. The new experiment runs on wood chips about 10 per cent of the time now, but is "all charged up and ready for winter," according to Herb O'Brien of the state buildings division.

Vermont began an experimental whole-tree harvesting industry at the adjacent Duxbury State Forest, with a contractor supplying chips for Waterbury. Problems in the $200,000 conversion project have included an unreliable supply of chips, fuel that contained too many twigs, and a wet wood supply that



Equipment used by Bill Sedlacek included this quartz crystal microbalance cascade impactor. It separates particles by size and weighs them, in small, nanogram quantities.

resulted from uncovered storage on the ground. But when the experiment is running smoothly, 40 tons of good hardwood chips creates only enough ash to fill a bucket two feet deep, said Waterbury fireman Fred McAdam.

The Vermont project has attracted interest from many quarters, including recent visits by Canadian officials. It's too early to say whether the plant is a complete success, said O'Brien, because everything was not on line until last February, and the first winter of operation — hopefully without hitches — is just beginning. A request has also been forwarded to the Vermont legislature, which meets in January, to provide more sophisticated fuel handling equipment. A semi-truck load of wood chips is required daily when the Waterbury boiler is running on wood. Other boilers are still oil-fired.

Future plumes?

Experiments at Waterbury were aimed at gathering data to use on S-2's computer model that shows how visual blight and haze can result from a power plant plume. The model was developed to predict the effects of combustion. Coal is deemed a major part of America's energy program for the next generation; air quality changes associated with burning it (or wood, or garbage) may affect people's health. Since a lot of the coal and many energy sites lie in the West, some national parks, monuments, and wilderness areas may also be affected.

A plume can be simulated by first taking an actual color slide of an outdoor area. This is digitized and the scene is modified to provide a new picture with either a power plant plume, background haze, or both. Then, a computer simulation of three wavelengths (red, green, and blue) is made. Concentrations of materials that scatter or absorb light are calculated along each line of sight. The densities in the simulated scene are converted to brightnesses and are displayed on a TV screen. Pictures are then taken of the TV image, giving S-2 a "before and after" look at emissions of a hypothetical plant. Mona Wecksung is S-2's computer graphics specialist, involved in this photographic technique with Evelyn Treiman, S-2 data analyst.

The model shows how visual blight can result from a plume; many coal and energy sites lie in the Rocky Mountain West.

The model can show not only to what extent a plume will destroy a region's scenic beauty, but also can determine whether one large plant or many smaller ones would be best for an area — considering terrain and weather. Procedures for siting plants in accordance with the country's Clean Air Act of 1977 may be easier with the model's help. Of the 29 million acres that the Secretary of the Interior has said may require visibility protection, 14 million acres are in the Rocky Mountain West.

A series of accompanying computer-generated photos show what happens with hypothetical plants. With a 3,000-megawatt coal facility, emissions are presumed to be 120 grams per second of fly ash, 1,750 grams of nitrogen oxides, and 500 grams of sulfur dioxide. These figures also presume that a scrubber removes 90 per cent of the sulfur dioxide before it reaches the stack top and 99.5 per cent of the particulates.

"We put the model together last year and are still testing it," said Leonard, S-2. "That's why we needed the measurements from Waterbury. Later, the model will be used for environmental assessments." Projects next year include a study of sulfur emissions from coal-fired power plants.

To verify the model, a simulated plume and an actual plume must be compared. The chemical composition of the gases must be known because many gases have light-absorbing properties that must be correctly modeled. The size distribution of the particulates will determine how visible light is scattered, affecting the plume's opacity. Infor-

Using a theodolite to track the course of weather balloons were Sumner Barr and Roline Baker, G-8.

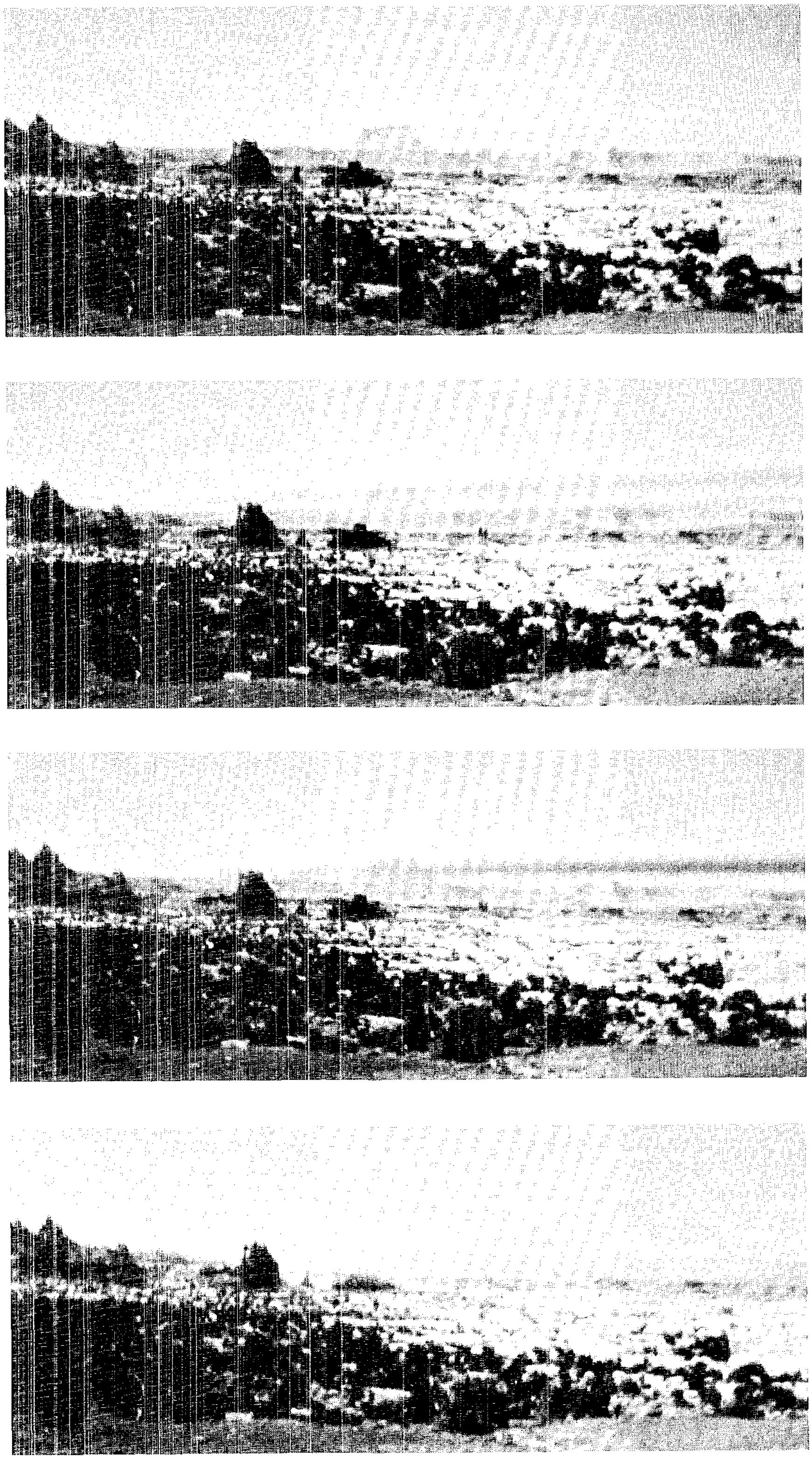
mation from Waterbury that includes size distribution and analyses of hydrocarbons and nitrogen oxides will be used in the model to visually recreate the plume. One application of the model is the scaling-up of plant size, as part of the Department of Energy study, to show what happens as the plume becomes larger.

Weather fits in

The model also requires meteorological data be available to determine the plume's travel direction and dispersion. Sounding balloons, each a meter in diameter, were released hourly by a G-8 team lead by Sumner Barr and their positions were tracked with a theodolite. A sensor on the balloons can transmit air temperature readings to the ground, and a profile of wind speed, temperature, and direction can be obtained as a balloon rises at 200 meters per minute and is tracked three to four kilometers above the ground. This technique has been used at several other study sites around the country and is valuable, yet inexpensive, said Clements, G-8.

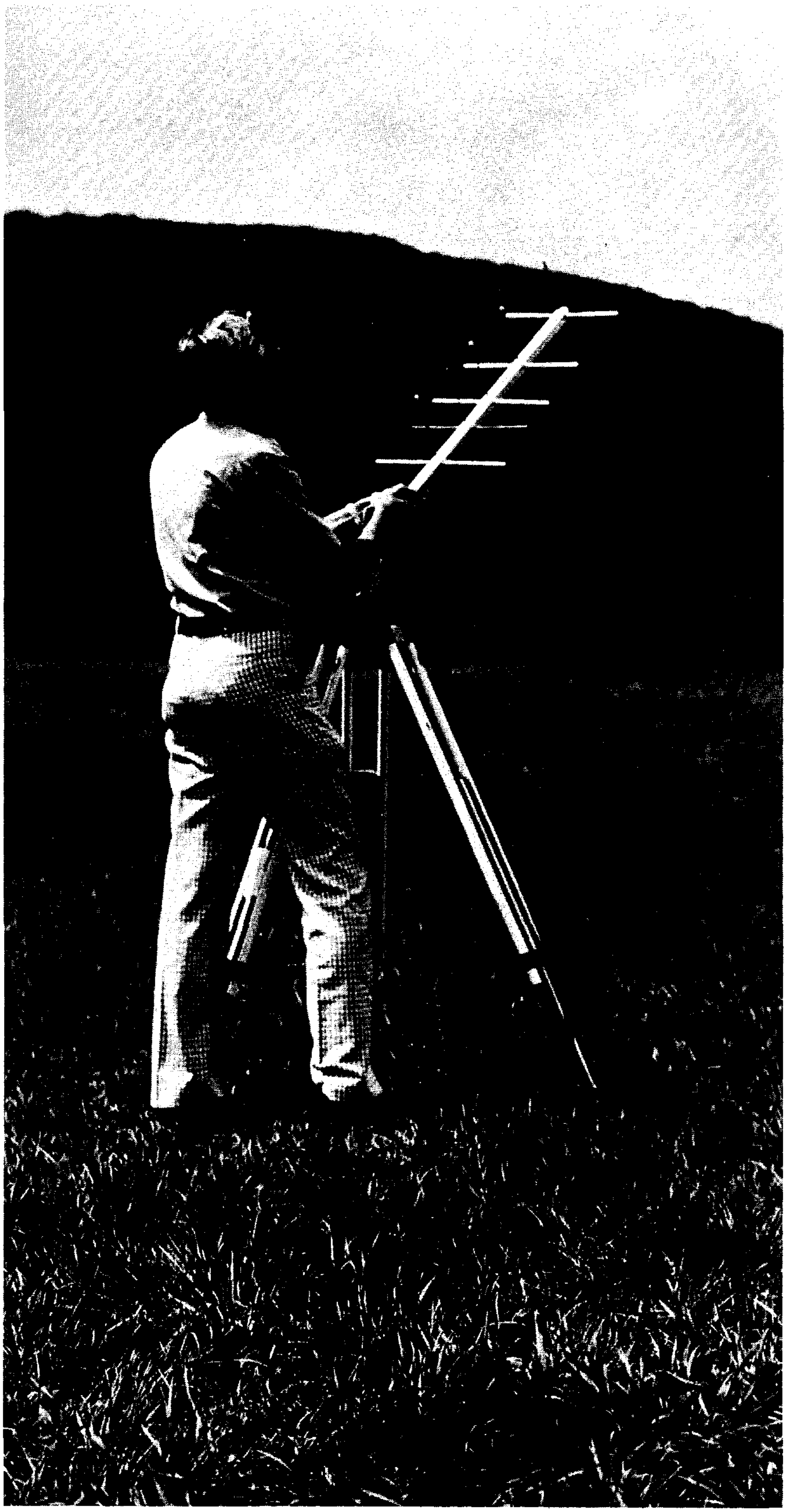
Tracer experiments, designed and conducted by Teymoor Gedayloo (G-8), introduced small fluorescent particles into the bottom of the chimney. The draft carried them out the top and downwind, where some of them were collected by samplers that have rotating sticky rods. The particles were counted, using special microscopes, to determine concentration patterns; red, yellow, and green particles distinguished releases made on the same day. These techniques have been used widely at Los Alamos to study the complex air movements in the canyon-mesa country of the Pajarito Plateau.

A surface wind survey determined patterns in the Waterbury area "airshed," similar in concept to drainage in a watershed. Kerry Wilson (G-8) used an electronic wind sensor at eight locations over a three-day period to map the surface wind speed and direction. Dan Peterson, University of New Mexi-



Evelyn Treiman photos

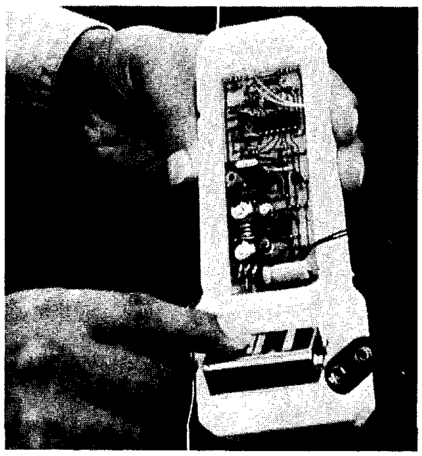
Pictures from a TV screen, using the computer model for hypothetical plumes. Top, a clean digitized picture of the natural scene. Then, two 1,000-megawatt coal plants with a scrubber; a 3,000 megawatt plant with an electrostatic precipitator; and lastly, general haze conditions.



Dan Peterson, University of New Mexico, used this receiver to read signals sent by temperature sondes attached to balloons.

Bill Clements released a weather balloon during the August study.

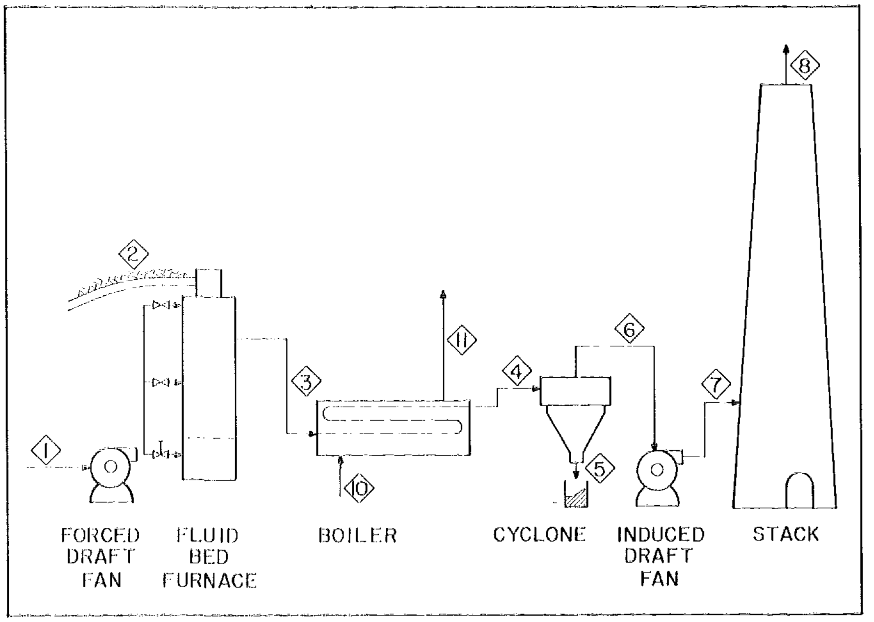
The weather was probed with balloons, fluorescent tracers, and wind sensors; Waterbury's climate is affected both by marine and continental air masses.



This "temperature sonde" is attached to a weather balloon with a 25-foot cord. It sends readings back to a ground-based receiver.

co, helped assess Waterbury's general climatology. Weather studies were supported by G-8 field personnel John Archuleta, Roline Baker, and Leonard Valerio. David Nochumson, S-2, operated Hivol air samplers to determine background concentrations of pollutants. Laura Szoo, S-2 summer student, assisted.

Waterbury lies along the Winooski River between folds of the Green Mountains that rise to over 1,000 meters. Both marine and continental air masses affect the fairly wet climate, where 40 inches of precipitation is recorded yearly. From an air quality view, G-8 noted, the worst conditions are associated with light winds and a shallow (100 to 300 meters) mixing layer where the plume is confined. Typical conditions are a mixing layer of 600 to 1,200 meters in winter and 2,000 to 3,000 meters in summer, with moderate winds from the south or northwest.



This schematic diagram displays the route taken by the wood chip fuel through the furnace, boiler, anti-pollution cyclone, and brick stack.

The wood debate

Is wood a feasible alternate fuel source? It is a matter of debate in Vermont, where everyone seems to own his or her private 10-acre plot, said state air quality engineer Cedric Sanborn in Montpelier. A state survey indicates that 75 per cent of Vermonters use wood as a primary or secondary fuel. A lot of wood-based industries, dealing in furniture, plywood, and paper, may ultimately waste half of their raw materials in the processing.

But can Vermont support a large wood-fueled power generator? Burlington Electric has already converted one of its three 10-megawatt units to wood, and has proposed a 50-megawatt plant to be run on alternate fuels. This plant, said Burlington Free Press writer William H. Braun, would amount to the area of a football field being clear-cut every two hours — 365 days a year. That would be 150,000 acres over a 30-year plant life.

Some officials say wood has better ultimate uses. In building, for instance, it's claimed that concrete or aluminum requires 15 to 20 times the energy needed to process wood materials. Lumber prices may increase by 50 per cent or more in the next 40 years, and wood is also becoming a basic industrial material.

All chemical feedstocks for plastics, pharmaceuticals, and synthetic fibers that now come from petroleum can also be produced from wood, according to Daniel Bousquet, a forest products marketing specialist from the University of Vermont. And there is pressure on the pulpwood and lumber industries, which use 85 per cent of the energy in the forest products field, to switch from gas and oil to wood. The Georgia-Pacific paper mill in Gilman, Vermont, was once the state's largest user of No. 6 fuel oil; it now uses wood exclusively.

There is an attendant debate over forest management. Much of the present New England forest was once cleared pastureland, but as farm use peaked a century ago, the land reverted. Regrowth, often from weak or misshapen trees, has been poor in terms of species mix and quality. Much of the best forests, including the "never-ending" stands of white pine, were cut long ago by logging companies — a pattern repeated across Michigan, Wisconsin, and Minnesota.

Wood's economic aspects

Wood can be burned to generate power internally, as at Waterbury, or used to fire an electrical generation plant. Commercial power apparently requires a new tree harvesting or chipping industry to supply large quantities of fuel, but this need not be the case.

A 50-megawatt plant would require 150,000 acres of trees over a 30-year lifespan.

The most efficient wood boilers are hand-stoked and were built 50 years ago.

In Eugene, Oregon, for instance, the municipal power department and the University of Oregon each operate a wood-fired plant. Area industries burn enough wood to fill a train of cars, each year, stretching from the Columbia River to the Mexican border. But the fuel used is waste wood and bark from mills, not wood harvested from a forest and destined directly for a power plant. Officials search for an even more efficient way to deal with debris, some seven million tons of which are generated as slash each year by logging operations within a 50-mile radius of Eugene.

Wood has roughly 40 per cent of the heat content of coal, or 25 per cent of the heat content of oil, on a weight basis. Transportation of the fuel can become quickly excessive: at a 100 mile distance, using 20-ton trailers, the cost of moving wood approximates the cost of raw coal alone. A prospective wood-burning facility, concluded S-2, is best located near an abundant wood supply. The use of wood plants may not be widespread, due not only to transportation, but also because commercially generated power may be available at an even lower cost. But they most likely will be one of the parts of an overall energy plan in the country, making their contribution in the face of dwindling fossil resources.

"Wood chipping is a whole new industry here," said Vermont engineer Sanborn. "Until Waterbury, there was no demand. In most areas of the state, there are trees, but you can't get them due to steep terrain. We get most of our electricity now from New Hampshire, Canada, Boston, and Niagara. Our nuclear plant at Vernon supplies 30 per cent, and we get 10-15 per cent from hydropower. We're kind of sitting here at everyone's mercy. Waterbury wasn't started just to save fuel, but to save dollars too."

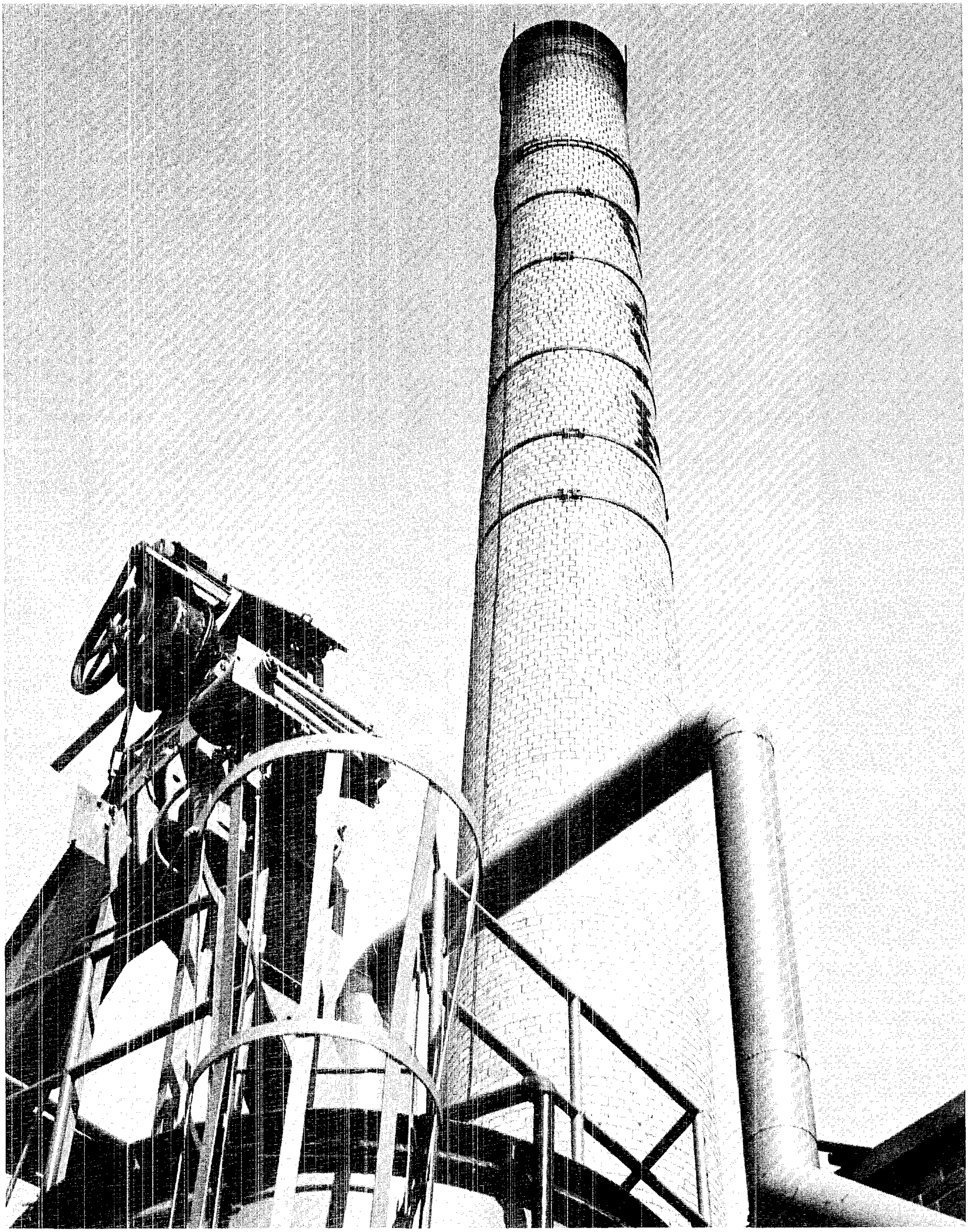
The Vermont legislature exempted wood plants from strict emission controls during the publicized energy crisis, and Sanborn's office lobbied to reinstate some standards. Many statewide tests have since been performed, ranging from studies of new wood boiler operations, to conversions, to boilers that have burned nothing but wood since they were installed in 1910. There are some 40 Vermont industries that burn wood.

1930 model best

"I've tested at least 12 different boilers," said Sanborn, "and the 1920-1930 hand-fired Dutch oven model had the lowest emissions. Many people have lost the knack of knowing how wood burns, and how to stoke a furnace — it's a real art. By cutting back on the air intake, there is a hotter fire and less fuel burned in many cases.

"The more we look at it, the more we understand it."

Cedric Sanborn, air pollution control engineer, in Montpelier, Vermont: "We're kind of sitting here at everyone's mercy. Waterbury wasn't started just to save fuel, but to save dollars too."



The 1925 Waterbury brick smokestack, with the top of the vessel where wood chips are fed down for combustion.

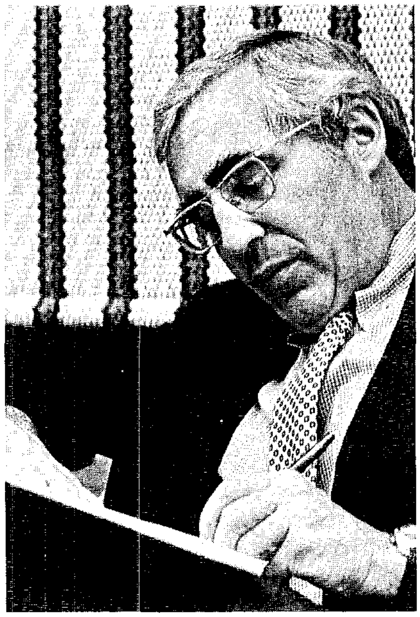
William Lehman, director of the Air Force Weapons Laboratory, spoke at a Los Alamos colloquium.

Among our guests

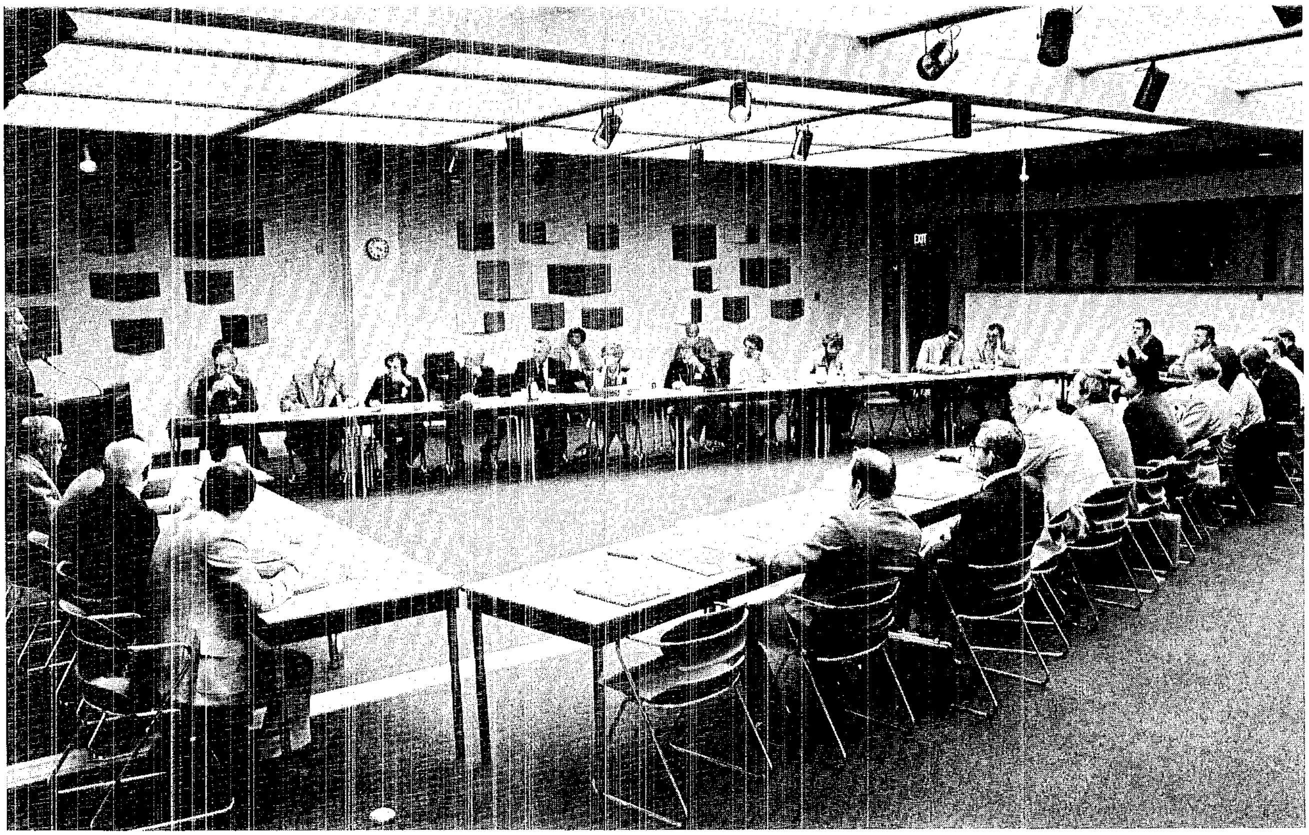
Photos by Bill Jack Rodgers

Robert Post, weapons examiner from the Office of Management and Budget, shared a joke during his stay with Ed Stein of the visitor relations group; Director Harold Agnew; and Robert Thorn, associate director for weapons.

Bob Henderson of the Weapons Planning Office helped brief Richard G. Stillwell (center) and Gordon Sumner, Jr. (right) during a briefing session. Both visitors are Laboratory consultants and are retired from the Army. Stillwell was commander-in-chief of the United Nations command in Korea; Sumner has been chairman of the Inter-American Defense Board, and now lives in Santa Fe.



Walter Pincus from the Washington Post checked his notepad before beginning another in a series of interviews with Laboratory officials recently.



Public information officers from weapons research-related installations gathered for the first such conference ever held to discuss common issues. The meeting began with a welcome by Director Harold Agnew and included presentations from different offices as well as LASL tours in October.

Archeology on the

Zia Company employees Jose Rendon and Palmita Osegeda excavate at Site LA-4629. What little useable land that existed was probably under cultivation.

Pajarito Plateau

EDITOR'S NOTE: This fourth and final article in a series discusses agriculture on the Pajarito Plateau. The other three articles appeared in the October, 1977, January-February, 1978, and April, 1978, issues of the *Atom*. Information was extracted from "Pajarito Plateau Archeological Survey and Excavations," compiled by Charlie Steen, LASL archeological consultant. The series was prepared for publication by John Armistead.

Agriculture was essential to the dwellers of the Pajarito Plateau. After many excavations of sites all over the plateau, ample evidence indicates the principal crop was maize.

Many charred and dessicated corn cobs have been found, and excavations have also yielded cucurbit (gourd-like) seeds and shells. Cleaned cotton has been found on the Plateau, but researchers surmise it was probably not grown here, but was cultivated at lower levels and transported.

No beans have been reported found on the Plateau. But archeologists feel there is no reason to doubt that beans, along with squash, pumpkins, and maize were common. Another domesticated plant, tobacco, has been identified from excavations in Frijoles Canyon.

What little useable land existed was probably under cultivation, investigations point out. At the upper reaches of the inhabited zone, all farming must have occurred on the mesa tops, as canyons are too narrow, steep, and cold to permit farming.

Only at lower elevations, where the canyons are shallow and wide, and there is plenty of alluvial soil, are there indications of primitive farming along the streams.

The Pajarito Plateau of the 14th century probably had widely dispersed house blocks of four to 20 rooms each, strung along the crest of a mesa. The clusters of houses were surrounded by fields where the soil was deep enough to cultivate. The mesa forest at the time of Indian habitation probably was about the same as it appears today. The Indians' need for wood in houses most likely would have helped to keep the forest thinned.

The mesa soils are thin, made up of decomposed tuff, and are from zero to less than 1.5 meters deep. Primitive farming methods are hard on any soil and would be particularly demanding on the Pajarito soil.

The usual American Indian method of harvesting was to pull the entire plant, no matter what the crop, and take it home. At the house, or in some nearby sheltered spot, a hard-packed clay floor served as a platform on which the harvest (ears of corn, cut-up squash, or beans) was spread to dry before being stored for the winter. Vines, leaves and stalks were piled near the house to serve as tinder.

Plant nutrients in the soil were quickly depleted with such a harvest system, and with no fertilizers being applied to the fields.

Evidence of site distribution indicates that at about the time Wiyo black-on-white pottery came into style (about 1325), the upper eleva-

A small shrine with a vertical post, set in a cobblestone floor, has been marked in Los Alamos Canyon (Site LA-14871).

tions of the mesas were largely abandoned; the population was concentrated below 2,000 meters (6,700 feet). Villages remained on the mesa tops where the soil was no better than at higher elevations, but from the mesas to the east were broad canyons and gentle slopes that could be cultivated.

In this part of the Plateau there are traces of check dams across drainage channels, both on the mesas and in the canyons.

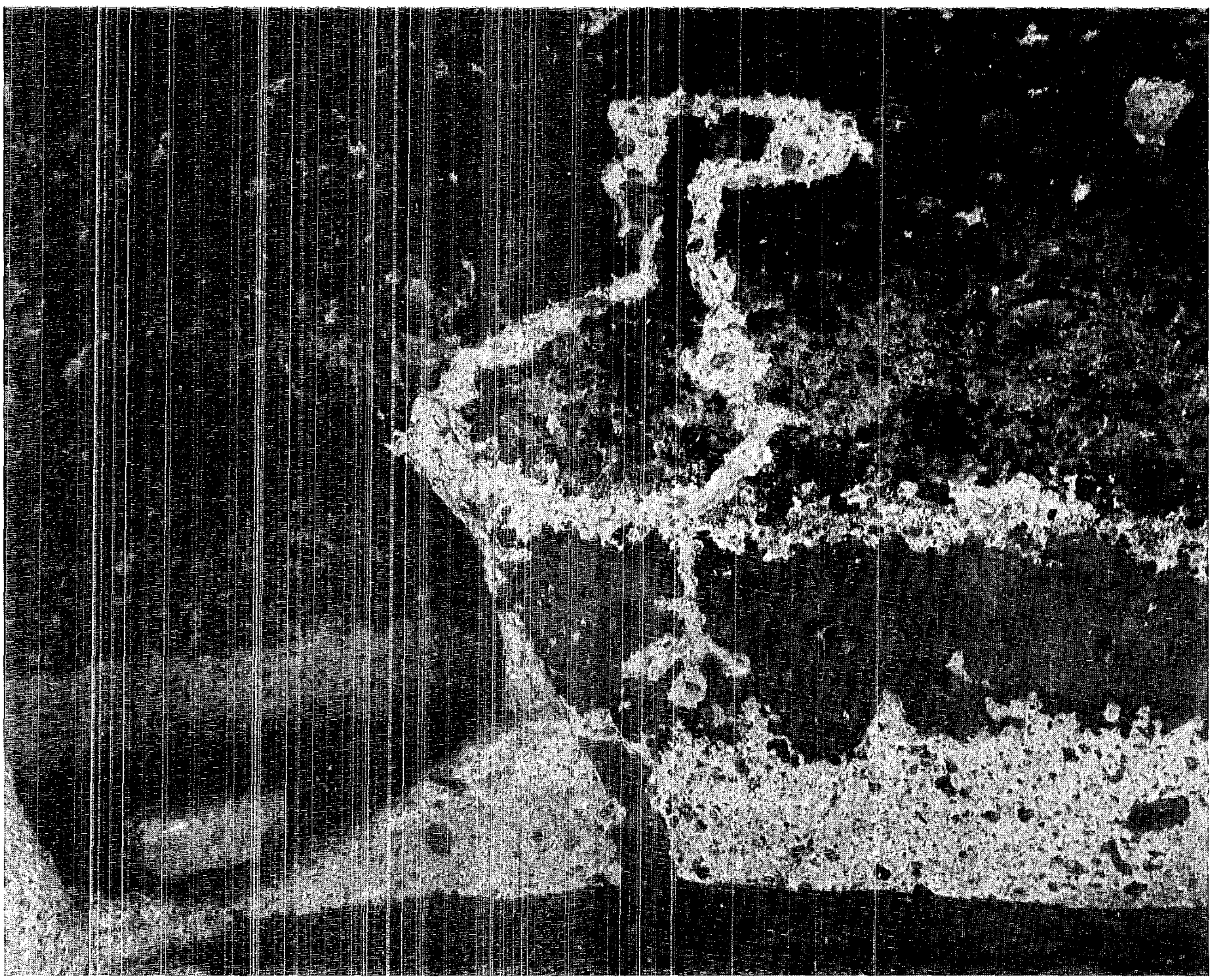
The most extensive agricultural plot seen during the investigations of the past few years was not on the Plateau, but on a terrace of the Rio Grande in White Rock Canyon, the Pajarito Springs site. Garden plots, terraces, and a few one-room field houses extend for about one kilometer on the sand and gravel terrace. A stone-lined ditch took water from Pajarito Creek to the vicinity of the fields, and smaller stone-lined ditches distributed water to the crops.

Steen feels that erosion of the surface of the mesas was negligible. In some places, serious channel cutting has occurred, and is still going on. The mesa tops and drainages between Pajarito and Fence Canyons and just west of Highway 4 are heavily cut by erosion, but Steen says the reasons for this are uncertain.

A second erosion area is on the lower end of Frijoles Mesa (within TA-33) where there apparently was heavy movement of tracked vehicles during World War II. Elsewhere on the mesas, channel cutting has been minor, and nearly everywhere erosion scars are now being covered with new growth.

A second type of erosion, termed "sheet erosion," is a general lowering of the surface due to runoff. There is no evidence of an appreciable amount of this kind of erosion.

All facts add up to strong evidence that there has been no significant change in the ground level of the Pajarito Plateau since the pre-Columbian occupation by Indians.



This bird pictograph appears in a 'cavate' kiva, and stands about one meter high. The hollowed area to the left may have been used for food storage.

Short Subjects

David Buden was appointed Energy (Q) Division leader for nuclear space power programs, effective August 15.

Karen S. Stoll became alternate group leader of ISD-4, Library Services Group, effective September 1.

Edward L. Jolly and *James C. Carpenter* were appointed assistant group leaders of L-1, Carbon Dioxide Laser Systems, effective June 1.

Joseph S. Ladish was appointed associate group leader of L-1, effective July 1.

L.A. Gritzo became Design Engineering (WX) assistant division leader for new technologies, and *L.W. Hantel* became WX-Division assistant division leader for reimbursable programs, each effective September 1.

Marvin L. Price was appointed assistant group leader of L-4 (Experiments and Diagnostics), effective September 1.

William L. Mudd was appointed assistant group leader for Computer Operations, Theoretical Design Division (TD-4), effective August 7.

Epifanio H. Trujillo was appointed assistant Supply and Property Department head for administration, effective August 1.

Albert P. Delgado became group leader of SD-7, Machine Rebuilding and Maintenance, effective October 1.

Edward Gritsko became group leader of SD-5, Branch Shops, effective October 1.

Reymundo J. Lopez became alternate group leader of ENG-2, Facilities Design, effective September 1.

Howard Lindberg became acting leader of a new group, E-9, Telecommunications, effective October 1. The Electronics Division section for minicomputer maintenance was transferred from E-5 to E-1.

Jack W. House was appointed associate J-9 group leader (Under-Ground Test Phenomenology), effective October 1.

Samuel D. Gardner became assistant Energy (Q) Division leader for safeguards, effective October 13.

Howard O. Menlove became group leader of Q-5, effective October 1.

Thomas J. Hirons became assistant for weapons, effective October 25.

Lon F. Alexander, Jr., became Eng-4 group leader (Maintenance, Engineering Department), effective September 1.

Earl O. Swickard became associate group leader at L-10 (High Energy Laser Development), effective August 1.

James C. Porter was appointed TD-2 group leader (Thermonuclear Weapons Design), effective October 16.

Two earn patent

United States Patent 4,095,121 has been granted to two Los Alamos researchers. They are Richard F. Begley, Laser Chemistry Group (AP-4), and Norman A. Kurnit, Tunable Laser Research and Development Group (AP-2).

According to the abstract, the patent involves a method and apparatus for achieving large susceptibilities and long interaction lengths in the generation of new wavelengths in the infrared spectral region. A process of resonantly enhanced four-wave mixing is employed, utilizing existing laser sources, such as the carbon dioxide laser, to irradiate a gaseous media.

10 Years Ago

CONGRESSIONAL VISIT

The New Mexico Northern District's brand new Congressman landed in Los Alamos this morning for his first official Laboratory briefing. The circumstances were vastly changed but the visit was far from Manuel Lujan Jr.'s first trip to the Hill. "Los Alamos seems like home to me — my roots here are very deep," the newly elected Congressman said. There was no doubt that he meant just that. Lujan's family owned Horse Mesa and had a ranch home there until the government took it over, and Lujan said he spent most of his childhood roaming over the Pajarito Plateau.

RUGS STOLEN

Six Navajo rugs valued at approximately $1,800 were stolen from Fuller Lodge sometime this weekend, Los Alamos police reported. The rugs have long hung in the main dining room at the Lodge. However, for a time while the Lodge was closed, the rugs were placed in storage. They were rehung last month. Since the rugs were AEC property, the FBI has entered the case.

AWARD TO *ATOM*

The Atom, house organ of the Los Alamos Scientific Laboratory, has won an "Award for Excellence" in the Pacific Industrial Communicators Association 1968 Evaluation and Awards Program. Three editions were entered in the competition.

TIME COLUMN

One hundred years from now a time column will be opened in Amarillo, Texas, and a group of scientists will examine its contents. The contents will all be related to helium. There are items collected by the U.S. Bureau of Mines from government and industrial laboratories which made significant contributions in the field of helium research. Included in the Bureau's 100-year Helium Centennial Time Column will be an item from LASL, a major contributor in the field. The Los Alamos exhibit contains plaques which highlight descriptive information about LASL and titles of technical papers and the names of authors whose discoveries contributed so much to the world's knowledge of helium at low temperatures.

Culled from the November, 1968 files of *The Atom* and the *Los Alamos Monitor* by Robert Y. Porton.

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There are many moods to autumn, and perhaps you can see some of them in this picture by PUB-1 photographer LeRoy N. Sanchez. The scene was a tributary of the Jemez River, not far from the Valles caldera.

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